

# ME 433, *Fundamentals of Air Pollution*

## Syllabus for Spring Semester 2024

John M. Cimbala, Penn State University. Latest update: 04 January 2024

**Lectures:** In-person lectures, and examples: **Mon, Wed, 1:25-2:15 in 114 Steidle Building.** Note that lecture videos, annotated notes, quizzes, & homework are all online (Canvas).

**Text:** *Introduction to Air Pollution Science*, R. F. Phalen and R. N. Phalen, Jones & Bartlett Learning, LLC, Burlington, MA – *recommended, but not required.*

**Prerequisites:** [ME 201](#) or [ME 300](#) or equivalent. Should also understand basic fluid mechanics and statistics.

**Instructor:**

- **John M. Cimbala**, [jmc6@psu.edu](mailto:jmc6@psu.edu). Professor of Mechanical Engineering, 234 Reber Building, 814-863-2739 [www.me.psu.edu/cimbala](http://www.me.psu.edu/cimbala). ← Weekly schedule is posted on this website.
- Office hours: **Mondays and Tuesdays 3:00-4:00 pm in 234 Reber Building.**

**TA:** **Ava Knaf**, [axk5854@psu.edu](mailto:axk5854@psu.edu) Office hours **Tuesday 1:00 to 3:00 pm in 127 Hammond.**

**Course Description:** This course is an introduction to air pollution, with an emphasis on outdoor rather than indoor air pollution. Topics to be covered include sources (emissions) of air pollution, both gaseous and particulate, interaction of air pollution with our bodies and the environment, and methods of measuring, quantifying, analyzing, and controlling air pollution. A brief introduction to government regulations related to air pollution will also be provided. Students are expected to be proficient in applying mathematics (e.g., integration, differentiation, and application of differential equations), and some basic chemistry, statistics, thermodynamics, and fluid mechanics. It is critical for many portions of this course that students know how to use software to solve equations, create plots, etc. Students can use any software they choose, such as Excel, Matlab, etc. Most of the class examples are in Excel.

**Web Pages:** The main website for this course is on Penn State's Canvas site at <https://psu.instructure.com/>. Professor Cimbala also maintains a second website at <http://www.me.psu.edu/cimbala/me433> where he will post lecture videos, etc. in the event that Canvas is down. Use this website only if you have trouble connecting or finding something on Canvas. Students are expected to check Canvas regularly for lecture notes and videos, homework assignments, quizzes, and other information. Hardcopies (handouts) of homework assignments will *not* be provided.

**Grading:** All quizzes, exams, and homework assignments are *comprehensive*, making use of previous material. **Automatic late penalties are given in Canvas for late submissions of homework and quizzes.**

<b>Homework</b>	<b>21%</b>	Highest 14 scores counted out of 15 total; due the <b>next</b> Tuesday each week at midnight
<b>Lesson Quizzes</b>	<b>60%</b>	Typically one quiz per lesson; due the <b>next</b> Tuesday each week at midnight; highest 60 scores counted out of expected 70 total (drop 10 lowest scores)
<b>Final Exam</b>	<b>19%</b>	<b>3 hours online during finals week – Tuesday 12:01 am through Thursday 11:59 pm</b>

**Grading Scale:** The following are minimum cutoffs for each grade:

<ul style="list-style-type: none"><li>• 90.00% = A</li><li>• 86.66% = A-</li><li>• 83.33% = B+</li></ul>	<ul style="list-style-type: none"><li>• 80.00% = B</li><li>• 76.66% = B-</li><li>• 73.33% = C+</li></ul>	<ul style="list-style-type: none"><li>• 70.00% = C</li><li>• 60.00% = D</li><li>• less than 60.00% = F</li></ul>
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**Course Objectives:** Upon completion of this course, students should be able to:

1. Identify substances (gases and particles) considered to be air pollutants, and how to quantify them.
2. Identify sources (emissions) of air pollutants, and how they disperse in the atmosphere.
3. Apply basic principles of thermodynamics and chemistry to model the formation of selected air pollutants.
4. Identify specific impacts of air pollution on human health and on the environment.
5. Identify and explain specific methods of controlling air pollution emissions.
6. Demonstrate knowledge of major air pollution legislation and its historical context.
7. Develop and practice skills in reading and interpreting the popular press and the scientific literature in regards to air pollution and climate change; in particular demonstrate ability to separate facts from rhetoric or opinion and to identify bias.
8. Read and summarize articles related to air pollution. [*Note: Students are expected to read newspaper, magazine, and/or Internet articles related to air pollution. USA Today, CDT, and NY Times are available free to all students.*]
9. Apply basic software tools (e.g., spreadsheets and Matlab) to the analysis of experimental data and mathematical models.
10. Demonstrate professionalism and respectful interaction with faculty and colleagues.

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**Lecture Schedule:** We will follow the schedule on the next page as closely as possible, *subject to change*. Note that the **Modules** on Canvas correspond to **Calendar Weeks** since there are 15 modules and 15 weeks in the semester.

Week #	Topics to be Covered
1	<b>MODULE 01: Introduction and Fundamentals:</b> chemistry review, volume flow rates, ideal gas mixtures (mole fractions, partial pressures, partial volumes, etc.), bulk molecular weight
2	<b>MODULE 02: Introduction and Fundamentals (continued):</b> concentrations, conversions, relative humidity, volatile liquids; <b>Classification of air pollutants:</b> EPA classifications (primary vs. secondary, CAPS, HAPS, NAAQS), visible air pollution, acid rain, ozone
3	<b>MODULE 03: Classification of air pollutants (continued):</b> sources of air pollution, global warming gases and climate change; <b>Emission factors:</b> how to estimate source strength, definition of efficiency of air pollution control systems (APCSs), combustion
4	<b>MODULE 04: Emission factors (continued):</b> flux chambers, tank filling; <b>Earth and the atmosphere:</b> Coriolis force, global wind patterns
5	<b>MODULE 05: Earth and the atmosphere (continued):</b> Lapse rate and atmospheric stability; <b>Gradient diffusion</b>
6	<b>MODULE 06: Plume dispersion:</b> Gaussian plume model, how to predict hazardous areas downwind of plumes
7	<b>MODULE 07: Gaussian puff diffusion:</b> how to predict hazardous areas downwind of a puff of air pollution; <b>Steam vs. particle plumes;</b> <b>Particulate air pollution:</b> Introduction
8	<b>MODULE 08: Particulate air pollution (continued):</b> particle number concentration, monodisperse and polydisperse aerosols, definitions, grade efficiency
9	<b>MODULE 09: Particle motion:</b> equations of motion, aerodynamic drag, particle settling speeds
10	<b>MODULE 10: Particle motion (continued):</b> gravimetric settling, elutriators, inertial separation in curved flows
11	<b>MODULE 11: Particle motion (continued):</b> how to predict grade efficiency in curved ducts, cyclone separators, Lapple standard cyclone, air cleaners in series and parallel
12	<b>MODULE 12: Particle Measurement:</b> cascade impactors, optical particle counters, sampling with probes, aerosol particle sampling issues; <b>Air pollution control systems (APCSs) for particulate matter (PM):</b> raindrops as air cleaners
13	<b>MODULE 13: APCSs for PM (continued):</b> spray towers, wet scrubbers, air filters, baghouses
14	<b>MODULE 14: APCSs for PM (continued):</b> electrostatic precipitators (ESPs); <b>Aerosol particle statistics:</b> mean, median, and geometric mean diameters, histograms, PDFs, cumulative distribution functions
15	<b>MODULE 15: Aerosol particle statistics (continued):</b> cumulative distribution functions and log-probability plots, geometric standard deviation, comparison of number and mass distributions;

**Grade Disputes:** If a student feels that an exam or homework was graded unfairly, or if there is an error in the grading, it should be brought to the attention of the grader (TA: homework, Professor: quizzes and exams) within one week after the material is graded except under extenuating circumstances.

**Cheating Policy:** Cheating is not tolerated in this course. You should refer to the Academic Integrity website at <http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx> which explains what behaviors are in violation of academic integrity, and the review process for such violations. On the next page is a summary of the policy. Specifically for this course:

- **First offense:** Zero score for the item in question, and infraction reported to the College.
- **Second offense:** Failure of the course, and infraction reported to the College.

**Summary of Penn State's Academic Dishonesty Policy:** The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to [Senate Policy 49-20](#)). Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic

sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to [Senate Policy G-9](#)).

Definition and expectations: Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle.

### **Accommodating Disabilities and Disability Access Statement:**

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Office for Disability Services (ODS) Web site provides contact information for every Penn State campus: <http://equity.psu.edu/student-disability-resources/disability-coordinator>. For further information, please visit the [Office for Disability Services Web site: http://equity.psu.edu/ods](http://equity.psu.edu/ods).

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Student Disability Resources Web site provides [contact information for every Penn State campus](#): For further information, please visit the [Student Disability Resources Web site: http://equity.psu.edu/student-disability-resources](http://equity.psu.edu/student-disability-resources). In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation. See <http://equity.psu.edu/student-disability-resources/applying-for-services>. If the documentation supports your request for reasonable accommodations, your [campus's disability services office](#) will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. You must follow this process for every semester that you request accommodations.

### **Counseling & Psychological Services (CAPS) Statement:**

CAPS can help students resolve personal concerns that may interfere with their academic progress, social development, and satisfaction at Penn State. Some of the more common concerns include anxiety, depression, difficulties in relationships (friends, roommates, or family); sexual identity; lack of motivation or difficulty relaxing, concentrating or studying; eating disorders; sexual assault and sexual abuse recovery; and uncertainties about personal values and beliefs. You can contact CAPS by calling the Main CAPS number/Appointment Scheduling: 814-863-0395 (Please call between the hours of 8am and 5pm, Monday-Friday to schedule an appointment) or visit us at our office location, 5th Floor Student Health Center.

### **Sexual Assault and Relationship Violence Hotline:**

A hotline has been established for victims and observers of sexual assault and relationship violence. Trained counselors on the hotline will help students access appropriate resources. Penn State students from any campus can call 1 (800) 560-1637 to access the 24 hour a day, seven day a week hotline.

### **Library Resources:**

Many of Penn State's library resources can be utilized from a distance. Through the University Libraries website, you can

- access magazine, journal, and newspaper articles online using library databases;
- borrow materials and have them delivered to your doorstep...or even your desktop;
- get research help via e-mail, chat, or phone using the [Ask a Librarian service \(Links to an external site.\)](#)[Links to an external site.](#); and much more.

You must have an active Penn State Access Account to take full advantage of the University Libraries' resources and services. Once you have a Penn State account, you will automatically be registered with the library within 24–48 hours. If you would like to check that your registration has been completed, visit the [Libraries home page \(Links to an external site.\)](#)[Links to an external site.](#), click on **Library Accounts**, and then click on **My Library Account**.

### **Academic Integrity:**

Academic integrity—scholarship free of fraud and deception—is an important educational objective of Penn State. Academic dishonesty can lead to a failing grade or referral to the [Office of Student Conduct \(Links to an external site.\)](#)[Links to an external site.](#) Academic dishonesty includes but is not limited to

- cheating,
- plagiarism,
- fabrication of information or citations,
- facilitating acts of academic dishonesty by others,
- unauthorized prior possession of examinations,
- submitting the work of another person or work previously used without informing the instructor and securing written approval, and
- tampering with the academic work of other students.

The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to Senate Policy 49-20). Dishonesty of any kind will

not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

### **How Academic Integrity Violations Are Handled:**

In cases where academic integrity is questioned, the [Policy on Academic Integrity \(Links to an external site.\)Links to an external site.](#) indicates that procedure requires an instructor to notify a student of suspected dishonesty before filing a charge and recommended sanction with the college. Procedures allow a student to accept or contest a charge. If a student chooses to contest a charge, the case will then be managed by the respective college or campus Academic Integrity Committee. If a disciplinary sanction also is recommended, the case will be referred to the [Office of Student Conduct \(Links to an external site.\)Links to an external site.](#) All Penn State colleges abide by this Penn State policy, but review procedures may vary by college when academic dishonesty is suspected. Information about Penn State's academic integrity policy and college review procedures is included in the information that students receive upon enrolling in a course. To obtain that information in advance of enrolling in a course, please contact us by going to the [Contacts & Help page \(Links to an external site.\)Links to an external site.](#)

Additionally, World Campus students are expected to act with civility and personal integrity; respect other students' dignity, rights, and property; and help create and maintain an environment in which all can succeed through the fruits of their own efforts. An environment of academic integrity is requisite to respect for oneself and others, as well as a civil community.

### **For More Information on Academic Integrity at Penn State:**

Please see the [Academic Integrity Chart \(Links to an external site.\)Links to an external site.](#) for specific college contact information or visit one of the following sites:

- Penn State Senate [Policy on Academic Integrity \(Links to an external site.\)Links to an external site.](#)
- [iStudy for Success! \(Links to an external site.\)Links to an external site.](#) (education module about plagiarism, copyright, and academic integrity)
- [Turnitin \(Links to an external site.\)Links to an external site.](#) (a web-based plagiarism detection and prevention system)